

Effect of less affected grip strength training on grip strength in both hands in unilateral cerebral palsy

Grip strength training

Aya T'Allah Y. Kandeel, Asma O. Sayed, Mohamed I. Elassal
Department of Pediatric, Faculty of Physical Therapy, Cairo University, Cairo, Egypt

Abstract

Aim: This study was performed to show the effect of less affected grip strength training on grip strength on both upper limbs and its impact on functional manual ability in children with unilateral cerebral palsy/hemiplegia.

Material and Methods: This study involved twenty-four children aged 7-12 years from both sexes with unilateral cerebral palsy or hemiplegia, whose degree of spasticity was 1 and +1 according to the modified Ashworth scale. Assessment of grip strength of both hands and functional manual ability were performed using a Camry Hand Held Dynamometer, a Manual Abilities Classification System, and a Pediatric Upper Extremity Motor Activity Log for pre- and post-training test. The Camry Hand Held Dynamometer was used for grip strength training of the less affected hand.

Results: This study revealed that less affected grip strength training showed a significant increase in grip strength on both upper limbs, with the mean strength gain on the more affected side being $58.06 \pm 27.88\%$, while that of the less affected side was $42.36 \pm 28.53\%$ compared with pre-training with improvement in functional manual abilities.

Discussion: This study showed a positive role of less affected grip strength training not only on ipsilateral but also on contralateral grip strength in improving functional manual abilities in children with unilateral cerebral palsy or hemiplegia, so this procedure may be used clinically in hand rehabilitation for them.

Keywords

Cerebral Palsy, Hemiplegia, Cross Education, Grip Strength

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Corresponding Author: Aya T'Allah Yasser Kandeel, Department of Pediatric, Faculty of Physical Therapy, Cairo University, 48 Sakr Kourish Buildings, El Maadi, Cairo, Egypt.

E-mail: drayayasser92@gmail.com P: +20 01116177812

Corresponding Author ORCID ID: <https://orcid.org/0000-0002-4893-6030>

Introduction

Cerebral Palsy (CP) is one of the most frequent neurological causes of motor disability in children that occurred in the developing fetal or infant brain leading to permanent disorders [1]. Unilateral Cerebral Palsy (UCP), also called Hemiplegic CP, upper-limb dysfunction can range from mild to profoundly impaired, depending on the timing, site, extent and nature of the brain lesion [2]. Deficits in timed motor performance and grip strength were noted in the less-affected (LA) hands of children with UCP compared to their typically-developing peers. Therefore, considering LA hand in intervention may be useful when considering the scope of clinical assessments and goal setting during rehabilitation [3].

Unilateral handgrip training program using the selected protocol increased handgrip strength bilaterally due to the cross-education of strength [4]. The cross-education of strength and skill learning was first discovered in 1894 by Scripture et al. who determined that muscular strength in contralateral limb could be improved following unilateral training. The mechanism behind the cross-education of the strength includes cortical and spinal adaptation, which alter the neural drive to the contralateral, untrained limb [5] and there is evidence for plasticity of interhemispheric connections to mediate cross-education produced by a simple motor task [6].

The Manual Ability Classification System (MACS) provides a new perspective for classifying manual ability in children and adolescents with CP. Parents and therapists have perceived the classification as meaningful description of variations in manual ability. Inter-rater reliability between parents and therapist, as well as between therapists was excellent; inter-rater reliability for different age groups was equally good [7].

The Pediatric Upper Extremity Motor Activity Log (PMAL) had high internal consistency and test-retest reliability. Convergent validity was supported by a strong correlation between changes in PMAL scores and the use of MA arm during playing [8].

Grip strength measurement is a well-known method to investigate hand function, providing insight into the combined action of a number of extrinsic and intrinsic muscles, and in several patient groups, grip strength measurement with a dynamometer is known to have excellent reliability [9].

Material and Methods

The study involved 24 children of both sexes with hemiplegia, aged 7-12 years from the outpatient clinic of Faculty of Physical Therapy, Cairo University Hospital and Modern University for Technology & Information. The local medical ethics committee at the University approved all study procedures. Written informed consent was obtained from all childrens' parents before participation in the study. This study involved children with grade 1 and 1+ spasticity according to the Modified Ashworth Scale who were able to sit independently and follow instructions. Children with a history of recent nonunion fracture, poor perception or cognition, and any contracture or deformity affecting hand mobility were excluded from this study.

The Modified Ashworth Scale (MAS) was used for the evaluation of spasticity. A Camry Dynamometer was used for the assessment of grip strength. The Manual Ability Classification System (MACS) and Pediatric Upper Extremity Motor Activity

Log (PMAL) were used for the functional manual ability assessment.

Before training, three baseline pre-tests were performed at intervals of 4-7 days. After training, one post-test was performed within 1 week. Maximal grip strength was performed in pre- and post- tests.

The Camry Dynamometer was used for grip strength training inform of 5 sets \times 5 repetitions \times 5 seconds of maximal grip contractions in the LA hand with a 3-second break between contractions and a 2- minute break between sets [4]. Before training, a warm-up session with 3 sets \times 5 repetitions \times 5 seconds 50% maximal grip contraction was completed. The training was performed in a comfortable sitting position, a less affected shoulder was adducted, 90 degrees elbow flexed forearm neutral with 0-15 degrees of ulnar deviation. The arm was not supported and the dynamometer was placed vertically and in line with the forearm.

Results

This study was performed to investigate the effect of LA grip strength training on grip strength in both hands in UCP, showing its impact on a child's functional ability quantitatively and qualitatively. Twenty-four children with hemiplegia participated in this study. The data obtained from the study groups pre- and post- training regarding grip strength of MA, grip strength of LA, PMAL and MACS were statistically analyzed and compared. The mean \pm SD age of the study group was 9.29 ± 1.62 years and the number of girls was 11 (46%), while the number of boys was 13 (54%). The distribution of the affected side in the study group revealed that 16 (67%) subjects had the right side affected and 8 (33%) subjects had the left side affected as shown in (Table 1).

The mean \pm SD grip strength of MA pre-training in the study group was 5.39 ± 1.95 kg, while post- training it was 8.22 ± 2.62 kg. The mean difference was -2.83 kg, so there was a significant increase in the grip strength of MA in the study group post- training compared to that pre- training ($p = 0.0001$), as shown in (Table 2) and (Figure 1).

The mean \pm SD grip strength of LA pre- training in the study group was 11.29 ± 3.25 kg, while post- training it was 15.78 ± 4.59 kg. The mean difference was -4.49 kg. There was a significant increase in the grip strength of LA in the study group post- training compared to that pre- training ($p = 0.0001$) as shown in (Table 3) and (Figure 2).

The mean \pm SD grip strength gain of MA in the study group was $58.06 \pm 27.88\%$, while that of the LA was $42.36 \pm 28.53\%$. The mean difference was 15.7%. There was a significant increase in the grip strength gain of MA compared to that of LA ($p = 0.02$) as shown in Figure 3.

The median (IQR) value of HO pre-training in the study group was 1.9 (2.45-1.3), while post-training it was 2.5 (3.27-2.22). There was a significant increase in the median value of HO in the study group post-training compared to that pre- training ($p = 0.0001$).

The median (IQR) value of HW pre-training in the study group was 2.1 (2.57-1.67), while post training it was 2.6 (3.3-2.5). There was a significant increase in the median value of HW in the study group post-training compared to that pre-training ($p = 0.0001$).

The median (IQR) grade of MACS pre-training of the study group was 2 (3-2), while post-training it was 2 (2-2). There was a significant change in MACS of the study group post-training compared to that pre- training (p = 0.001).

Table 1. Descriptive statistics for the study group

	Number	%
Age(mean ±SD)	9.29 ± 1.62	
Gender		
Girls	11	46
Boys	13	54
Affected side		
Right side	16	67
Left side	8	33

Table 2. Comparison between pre- and post- training mean values of grip strength of MA in the study group.

Grip strength of MA (kg) $\bar{x} \pm SD$		MD	t- value	p-value	Sig
Pre	5.39 \pm 1.95	-2.83	-9.76	0.0001	S
Post	8.22 \pm 2.62				
\bar{x} : mean SD: Standard deviation		MD: mean difference			
t-value: Paired t-value p-value: Probability value		S: Significant			

Table 3. Comparison between pre- and post- training mean values of grip strength of LA in the study group.

	Grip strength of LA (kg) x̄ ± SD	MD	t- value	p-value	Sig
Pre	11.29 ± 3.25	-4.49	-7.92	0.0001	S
Post	15.78 ± 4.59				

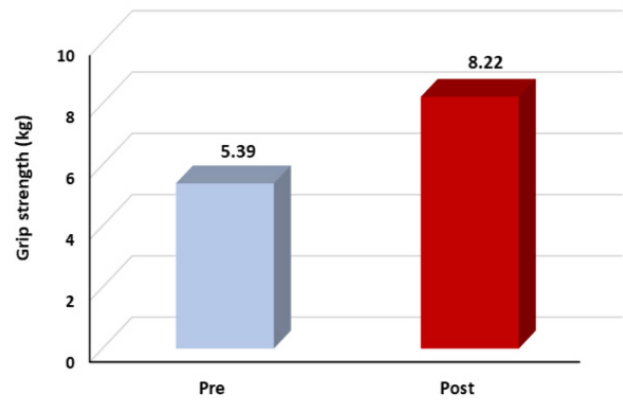


Figure 1. Pre- and post- training mean values of grip strength of MA in the study group.

Discussion

The main aim of this study was to determine the effect of training of grip strength of LA side on grip strength bilaterally and functional manual ability in children with hemiplegia, regardless of etiological causes. This study involved twenty-four participants aged from seven to twelve years, with hemiplegia with a degree of spasticity of 1 and +1 according to MAS. Three baseline pre-tests, separated by 4-7 days, and one post-test within 1 week after training

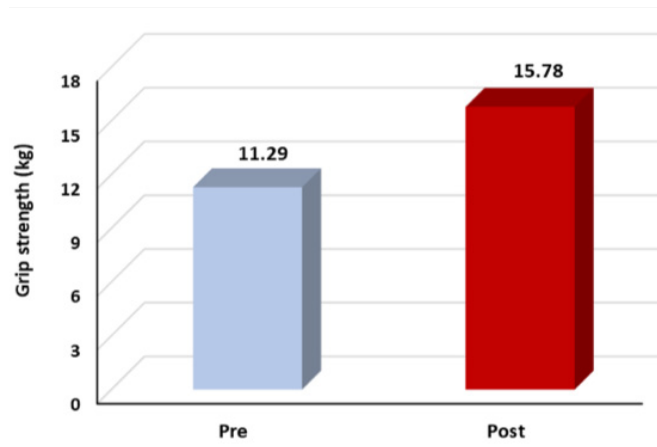


Figure 2. Pre- and post- training mean values of grip strength of LA of the study group.

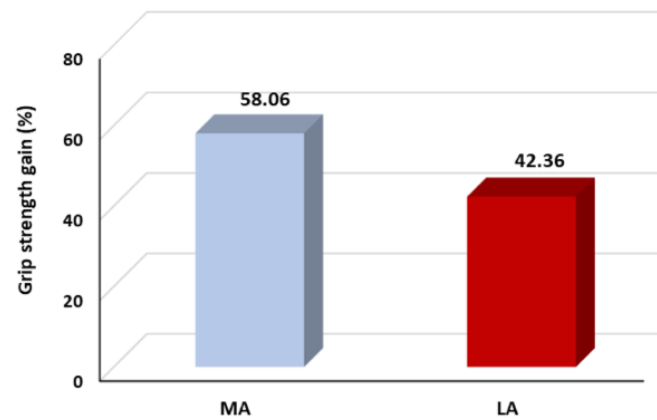


Figure 3. Mean values of grip strength gain of MA and LA in the study group.

were performed for assessment. Although this design required more time and labor, it has been validated as a replacement of the control group. MACS and PMAL were used for manual functional ability assessment, while the Camry dynamometer was used for grip strength assessment. The MACS can be reliably used for children between 4 and 18 years of age [10]. Despite its advantages, MACS was not designed to classify UCP children in an objective way [11]. A handgrip dynamometer is a reliable measurement when standardized methods and calibrated equipment are used, even when there are different assessors or different brands of dynamometers [12]. Grip strength training was performed for 5 weeks inform of 3 sessions per week [4]. This study included 24 children with hemiplegia of both sexes: 11 girls (46%) and 13 boys (54%); their mean age was 9.29 ± 1.62 years. The result showed that grip strength training of LA increased the voluntary grip strength for both the LA and MA sides with a significant increase in the grip strength gain for MA compared to that of LA (p = 0.02) and significantly changed manual functional ability, which may be induced by cross-education phenomena. Cross-education phenomenon was used in patients with unilateral injuries, such as knee osteoarthritis, tendinopathy, fracture, stroke, and cerebral palsy, which are extremely common [13], and it was observed that unilateral training induced contralateral gains in strength with a moderate to large

magnitude [14], but it was reported that there were only modest effects and limited clinical relevance for this phenomenon [15]. Thus, this study was performed to show the efficacy of this training in pediatric hand rehabilitation specifically in children with hemiplegia, and this study results showed a more significant increase in strength gain in both trained and untrained sides (LA and MA). A recent meta-analysis showed that a cross-education strength gain was 18% in young adults, 15% in older adults and 29% in a patient population [16], and our study strength gain of MA was $58.06 \pm 27.88\%$. Thus, cross-education impact may be greater in children than in adults and the elderly, which will need more research.

This study showed that the median grade of MACS pre- training was 2 (3-2), while post- training it was 2 (2-2), the median value of HO pre- training was 1.9 (2.45-1.3), while post- training it was 2.5 (3.27-2.22), and the median value of HW pre- training was 2.1 (2.57-1.67), while post-training it was 2.6 (3.3-2.5). It can be concluded that there was a significant change in MACS post-training compared to that pre- training ($p = 0.001$), a significant increase in the median value of HO post- training compared to that - training ($p = 0.0001$), and a significant increase in the median value of HW post- training compared to that pre- training ($p = 0.0001$).

There were many positive comments from some caregivers that the child started using the MA side much better in some activities of daily living, one of these comments was that MA hand movements started to be more precise and tremor-like movements were less than before training, which may be related to the increased activation found within the cerebellum due to cross-education training that may lead to improved timing and activation of agonists, antagonists and synergist muscle groups, which improve the coordination of a movement task [17]. There are some limitations in our research. Many of the participants apologized that they unable to come three times per week, so instead of taking only five weeks for treatment they take more weeks to complete 15 sessions and some of them were unable to complete the entire protocol due to pandemic COVID-19.

Conclusion

It can be concluded that grip strength training on less affected side can be clinically used in the future as a new procedure for pediatric rehabilitation specifically for children with hemiplegia to increase not only their grip strength bilaterally, but also to improve their functional manual ability, making their life better.

Scientific Responsibility Statement

The authors declare that they are responsible for the article's scientific content including study design, data collection, analysis and interpretation, writing, some of the main line, or all of the preparation and scientific review of the contents and approval of the final version of the article.

Animal and human rights statement

All procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. No animal or human studies were carried out by the authors for this article.

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Conflict of interest

None of the authors received any type of financial support that could be considered potential conflict of interest regarding the manuscript or its submission.

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